NASA Facts

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Active Aeroelastic Wing Flight Research

Historical Background

When Orville Wright first took to the air on Dec. 17, 1903, he didn't have ailerons or flaps to control his airplane. Instead, the Wright brothers had chosen to twist or "warp" the wingtips of their craft in order to control its rolling or banking motion. Rather than using one of the craft's two control sticks to make the wingtips twist, they had devised a "saddle" in which the pilot lay. By moving his hips from side-to-side, the pilot warped either the left or right wingtip, providing the necessary flight control for the aircraft.

Project Summary

NASA's Dryden Flight Research Center, Edwards, Calif., in cooperation with the U.S. Air Force Research Laboratory (AFRL) and Boeing Phantom Works, is researching this "wing-warping" approach in the Active Aeroelastic Wing (AAW) flight research program. The focus of AAW research is on developing and transitioning the application of aeroelastic tailoring-based active flexible wing concepts through which traditional aircraft control surfaces, such as ailerons and leading-edge flaps, will be used to twist a flexible wing. Roll maneuvering will be controlled by this warping of the aircraft's wings. The test aircraft chosen for the AAW research is a modified F/A-18A obtained from the Navy in 1999.

Current Status

Begun in 1996, the AAW flight research program has completed detailed design, and the wing modifications required for the program have been completed. Installation and checkout of flight test instrumentation, including specialized research computers, will continue through 2000 and into 2001. Research flights are expected to begin in mid-2001, and continue for about 18 months**.**

Goals

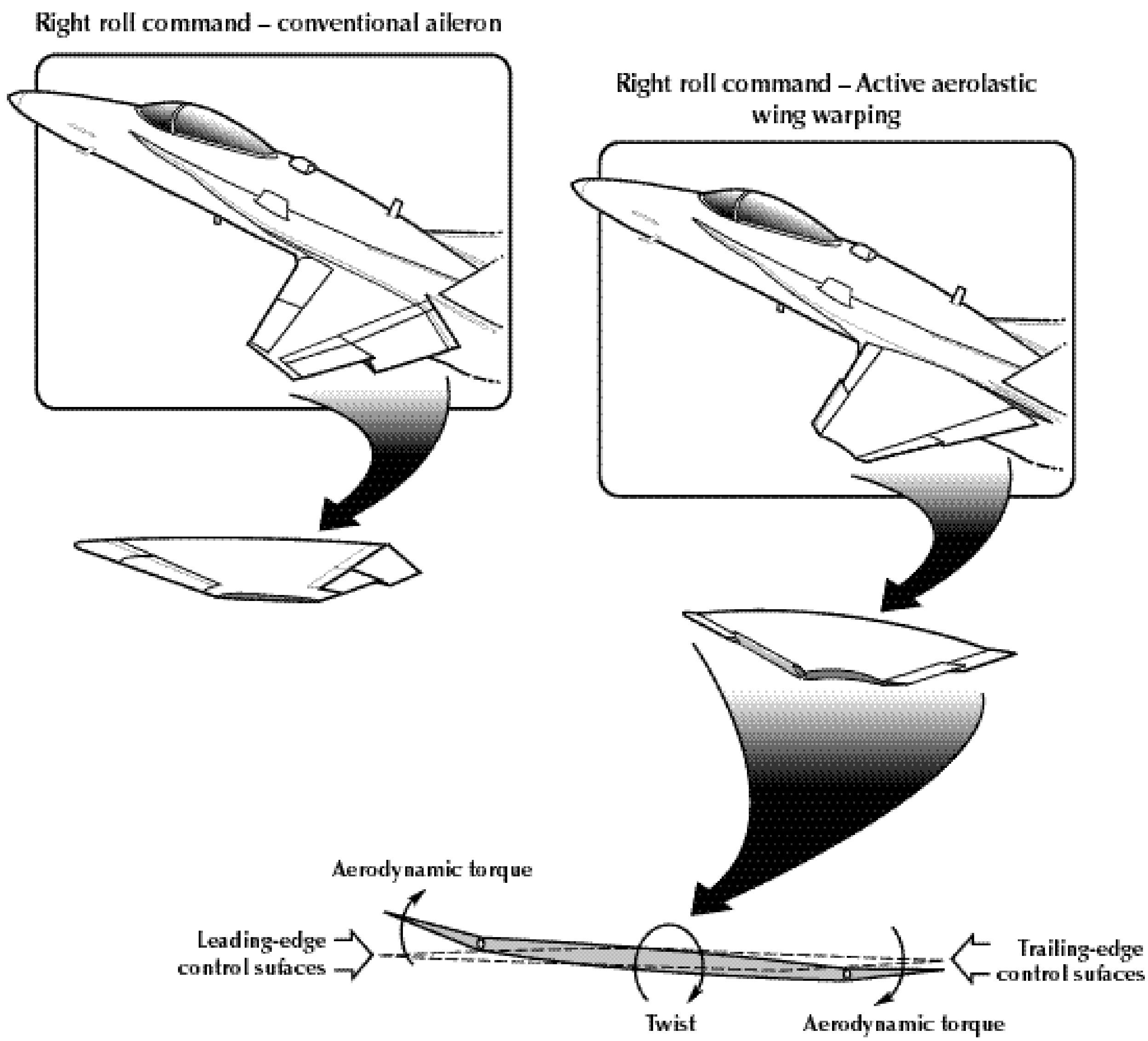
The research program will evaluate the AAW concept, with the goal of developing flight data for transonic and supersonic flight. The flight data will include aerodynamic, structural and flight control characteristics that demonstrate and measure the AAW concept in a comparatively low cost, effective manner. The data also will provide benchmark design criteria as guidance for future aircraft designs.

Aircraft Modifications

The wings from Dryden's F-18 #840, formerly used in the High-Alpha Research Vehicle (HARV) program, have been modified for the AAW flight research program. Several of the existing wing skin panels along the rear section of the wing just ahead of the trailing-edge flaps and ailerons have been replaced with thinner, more flexible skin panels and structure, similar to the prototype F-18 wings.

Original F-18 wing panels were light and flexible. During early F-18 flight tests the wings were observed to be too flexible at high speeds for the ailerons to provide the specified roll rates. This was because the high aerodynamic forces against a deflected aileron would cause the wing to deflect in the opposite direction.

Additional actuators have also been added to operate the outboard leading-edge flaps separately from the inboard leading-edge



Comparison of conventional and active aerolastic wings.

surfaces. By using the outboard leading-edge flap and the aileron to twist the wing, the aerodynamic force on the twisted wing will provide the roll forces desired. Now, a flexible wing will have a positive control benefit rather than a negative one.

In addition to the wing modifications, a new research flight control computer is being developed for the AAW test aircraft, and extensive instrumentation—including more than 350 strain gauges—have been installed on each wing.

Funding

The AAW project receives its funding from NASA's Office of Aero-Space Technology, as well as from the U.S. Air Force Research Laboratory. The Boeing Company's Phantom Works division in St. Louis, Mo., performed the AAW wing modifications, installed portions of the wing instrumentation and assisted in software development under contract with the Air Force Research Laboratory and NASA. The total budget for the entire AAW project is approximately $30 million, spread over eight years.

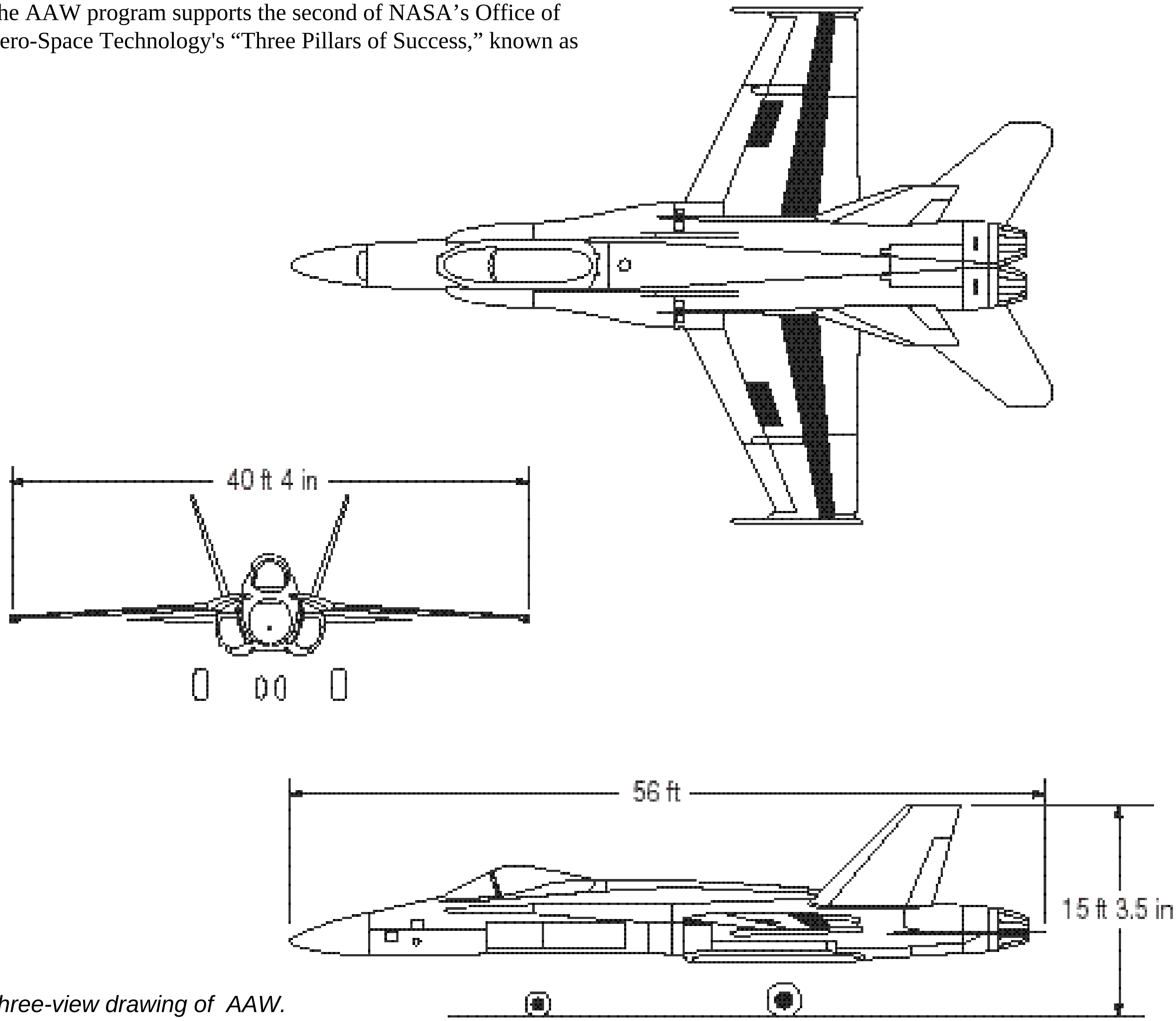
"Technology Pillar" Support

The AAW program supports the second of NASA's Office of Aero-Space Technology's "Three Pillars of Success," known as "Revolutionary Technology Leaps." In particular, AAW is part of the pillar's goal of providing next-generation design tools and experimental aircraft to increase design confidence, cutting the design cycle time for aircraft in half.

NASA's technology pillars represent the Agency's aggressive long-range goals. Aero-Space Technology is one of the four NASA Strategic Enterprises established to address key agency activities in distinctly different areas.

Technology Commercialization

Through these wing warping techniques, aircraft wing weight can be lowered, radar signature can be minimized and drag can be reduced, increasing fuel efficiency. It is believed that a future aircraft designed with AAW technology could be 10 to 20 percent lighter. In addition, aircraft wing designers will have greater freedom in designing more efficient, higher aspect-ratio wings for future aircraft.



Three-view drawing of AAW.